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Technical Report

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LFP User's Manual (Lincoln FORTRAN Preprocessor) Version 02.01 for MODCOMP Systems

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J.M. Sivak

12 May 1981

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This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

LFP USER'S MANUAL (LINCOLN FORTRAN PREPROCESSOR) VERSION 02.01 FOR MODCOMP SYSTEMS

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Group 47

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ABSTRACT

LFP (Lincoln Fortran Preprocessor) provides top-down control structures to Fortran and generates a self-documenting structured listing. LFP is compatible with existing Fortran and also permits an internal procedure capability.

CONTENTS

LIST OF ILLUSTRATIONS

1.0 INTRODUCTION

The Lincoln Fortran Preprocessor (LFP) Fig. 1-1 was constructed to facilitate structured programming by extending FORTRAN to include the most useful top down control structures. The choice of FORTRAN for a target language was dictated by its being the only higher level language available on many mini-computers. This work was motivated by a desire to make top-down structured programming tools available for the development of FORTRAN software.

LFP is an upward compatible extension of FORTRAN which provides five new top down decision structures, five additional loop structures and an internal procedure capability. In addition to structured control, LFP provides a neat, automatically-formatted, structured listing. The ease of program construction and clarity of program documentation are greatly enhanced thus reducing the clerical detail and the likelihood of programming in bugs.

At Lincoln Laboratory, LFP is implemented on a Modcomp 4 under MAX 4-rev D operating system and on an Amdahl 470 with the CP/CMS operating system.

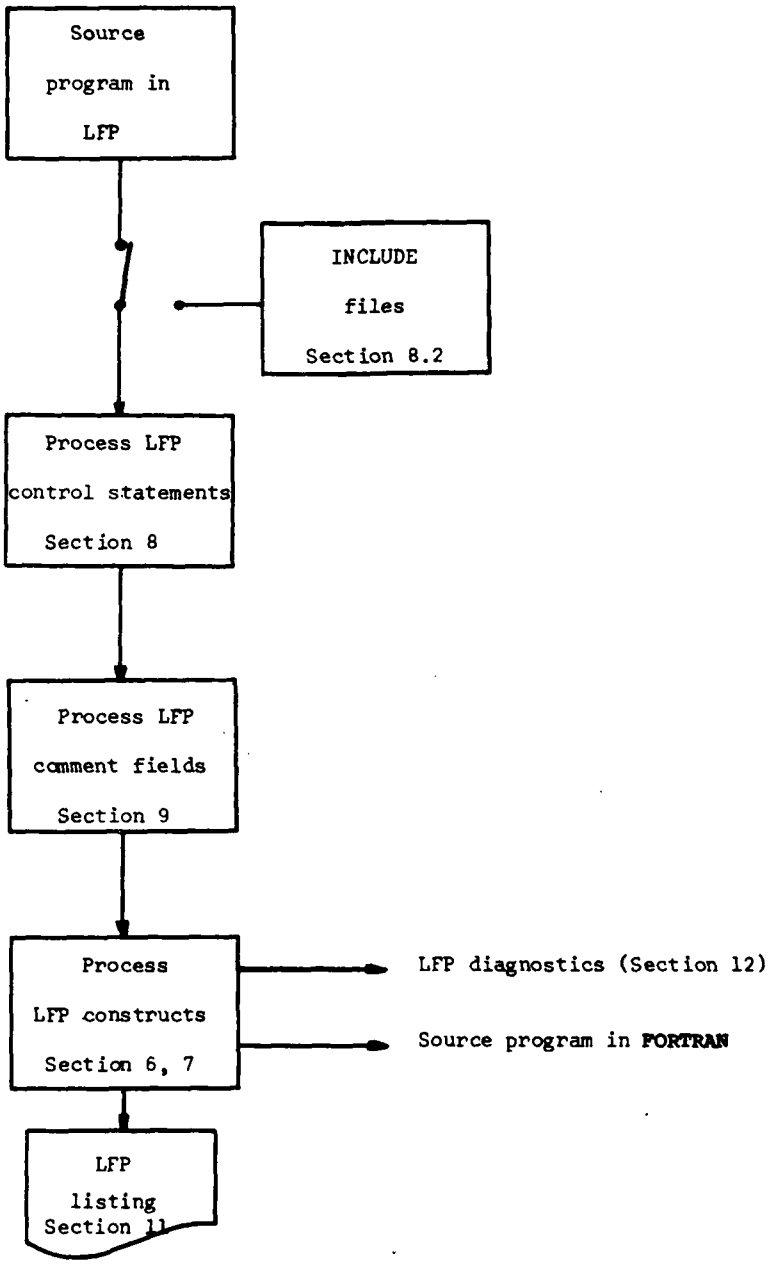


Fig. 1-1. LFP Preprocessor.

2.0 RETENTION OF FORTRAN FEATURES

The LFP translator examines each statement in the LFP program to see if it is an extended statement (a statement valid in LFP but not in FORTRAN). If it is recognized as an extended statement, the translator generates the corresponding FORTRAN statements. If, however, the statement is not recognized as an extended statement, the translator assumes it must be a FORTRAN statement and passes it through unaltered. Thus the LFP system does not restrict the use of FORTRAN statements, it simply provides a set of additional statements which may be used. In particular, GO TOs, arithmetic IFs, CALLs, arithmetic statement functions, and any other FORTRAN statements, compiler dependent or otherwise, may be used in LFP programs.

3.0 CORRELATION OF LFP AND FORTRAN SOURCE

A basic flaw in most FORTRAN preprocessors' output is the inability to correlate the preprocessor source listing with compiler syntax or run-time errors. This usually forces the user to list the FORTRAN source that was generated by the preprocessor and to attempt to make sense out of the generally unreadable FORTRAN.

The philosophy inherent in the LFP design was simple: Let LFP work in the same numbering system as the FORTRAN compiler, since all compiler errors or execution errors refer to this numbering system. However, not all compilers number the statements the same way. IBM FORTRAN G and H compilers number every statement except comment and continuation lines while CDC and MODCOMP compilers number every statement.

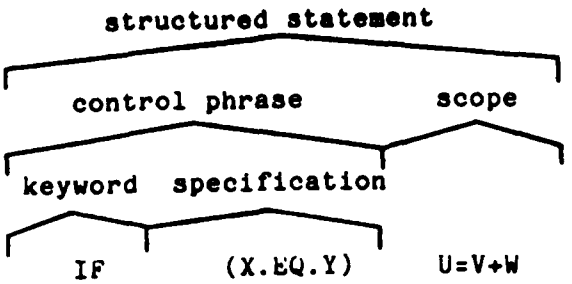
The statement identification field (line tag) that is present in columns 73 to 80 of the user's source program, if one is present, may at the option of the user be printed on the LFP listing along with the statement. The FORTRAN source generated by LFP may also contain this statement identifier.

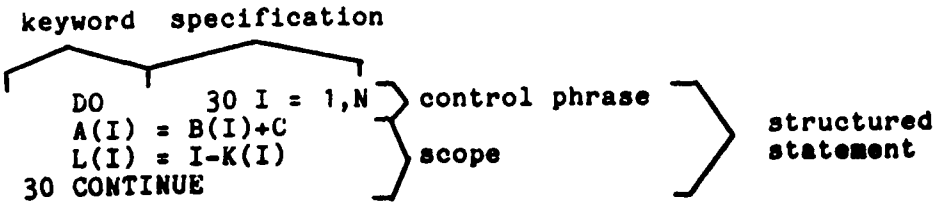
It is possible to specify exactly what type of line numbering scheme is to be used by LFP with a LABEL control statement. (See Section 8.1.5.)

A sample of a source program processed by LFP along with the compiler listing output may be found in Section 11.

4.0 STRUCTURED STATEMENTS

A basic notion of LFP is that of the structured statement which consists of a control phrase and its scope. FORTRAN has two structured statements, the logical IF and the DO. The following examples illustrate this terminology:





Note that each structured statement consists of a control phrase which controls the execution of a set of one or more statements (its scope).

Each control phrase consists of a keyword plus some additional information called the specification. A statement which does not consist of a control phrase and a scope is said to be a simple statement. Examples of simple statements are assignment statements, subroutine CALLs, arithmetic IFs, and GO TOs.

The problem with the Fortran logical IF statement is that its scope may contain only a single simple statement. This restriction is eliminated in the case of the DO, but at the cost of clerical detail (having to stop thinking about the problem while a statement number is invented).

In LFP there is a uniform convention for writing control phrases and indicating their scopes. To write a structured statement, the keyword is placed on a line beginning in column 7 followed by its specification enclosed in parentheses. The remainder of the line is left blank. The statements comprising the scope are placed on successive lines. The end of the scope is indicated by a FIN statement. This creates a multi-line structured statement. Examples of multi-line structured statements:

```
IF (X.EQ.Y)
|  U = V+W
|  R = S+T
|_FIN

DO (I = 1,N)
|  A(I) = B(I)+C
|  C = C*2.14-3.14
|_FIN
```

Note: The statement number has been eliminated from the DO specification since it is no longer necessary, the end of the loop being specified by the FIN.

Nesting of structured statements is permitted to any depth.

Example of nested structured statements:

```
IF (X.EQ.Y)
|  U = V+W
|  DO (I = 1, N)
|  |  A(I) = B(I)+C
|  |  C = C*2.14-3.14
|  |_FIN
|  R = S+T
|_FIN
```

When the scope of a control phrase consists of a single simple statement, it may be placed on the same line as the control phrase and the FIN may be dispensed with. This creates a one-line structured statement.

Since each control phrase must begin on a new line, it is not possible to have a one-line structured statement whose scope consists of a structured statement:

Example of invalid construction:

```
IF (X.EQ.Y) DO (I = 1,N) A(I) = B(I)+C
```

To achieve the effect desired above, the IF must be written in a multi-line form.

Example of valid construction:

```
IF (X.EQ.Y)
|  DO (I = 1,N) A(I) = B(I)+C
└─FIN
```

In addition to the IF and DO, LFP provides several useful structured statements not available in FORTRAN. After a brief excursion into the subject of indentation, we will present these additional structures.

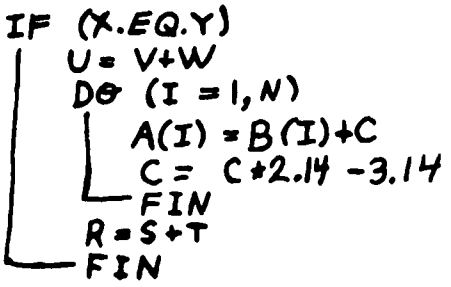
5.0 INDENTATION DESCRIPTION

In the examples of multi-line structured statements above, the statements in the scope were indented and an "L" shaped line was drawn connecting the keyword of the control phrase to the matching FIN. The resulting graphic effect helps to reveal the structure of the program. The rules for using indentation and FINs are quite simple and uniform. The control phrase of a multi-line structured statement always causes indentation of the statements that follow its scope. Nothing else causes indentation. A level of indentation (i.e., a scope) can only be terminated with a FIN.

When writing an LFP program on paper, the programmer should adopt the indentation and line drawing conventions shown below. When preparing a LFP source program in machine readable form, however, each statement should begin in column 7. When the LFP translator produces the listing, it will reintroduce the correct indentation and produce the corresponding lines. If the programmer attempts to introduce his own indentation with the use of leading blanks, the program will be translated correctly, but the resulting listing will be improperly indented. The source may be left adjusted to column 7 before processing by the use of the LADJ control card. See Section 8.1.6.

Example of indentation:

1. Program as written on paper by programmer.



2. Program as entered into computer:

```
IF (X.EQ.Y)
U = V+W
DO (I = 1,N)
A(I) = B(I)+C
C = C*2. 14-3. 14
FIN
R = S+T
FIN
```

3. Program as listed by LFP translator:

```
IF (X.WQ.Y)
.  U = V+W
.  DO (I = 1,N)
.  .  A(I) = B(I)+C
.  .  C = C*2.14-3.14
.  ...FIN
.  R = S+T
...FIN
```

The correctly indented listing is a tremendous aid in reading and working with programs. Except for the dots and spaces used for indentation, the lines are listed exactly as they appear in the source program. That is, the internal spacing of columns 7-72 is preserved. There is seldom any need to refer to a straight listing of the unindented source.

6.0 CONTROL STRUCTURES

The complete set of control structures provided by LFP is described in the following subsections together with their corresponding flow charts. The symbol $\mathcal{L}$ is used to indicate a logical expression. The symbol $\mathcal{S}$ is used to indicate a scope of one or more statements. Some statements, as indicated, do not have a one-line construction.

A convenient summary of the information in this chapter may be found at the end of this section and in Appendix A.

6.1 Decision Structures

Decision structures are structured statements which control the execution of their scopes on the basis of a logical expression or test.

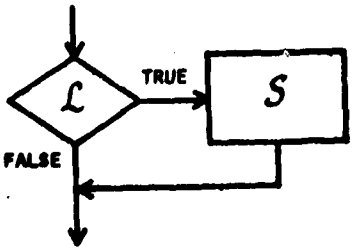
6.1.1 IF

Description: The IF statement causes a logical expression to be evaluated. If the value is true, the scope is executed once and control passes to the next statement. If the value is false, control passes directly to the next statement without execution of the scope.

General Form:

IF ($\mathcal{L}$) $\mathcal{S}$

Flow Chart:



Examples:

```
IF (X.EQ.Y) U = V+W

IF (T.GT.0.AND.S.LT.R)
.  I = I+1
.  Z = 0.1
...FIN
```

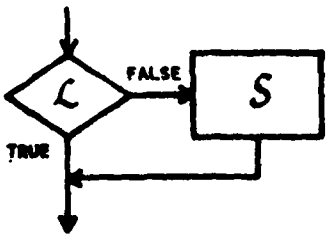
6.1.2 UNLESS

Description: "UNLESS ($\mathcal{L}$)" is functionally equivalent to "IF(.NOT.($\mathcal{S}$))", but is more convenient in some contexts.

General Form:

UNLESS ($\mathcal{L}$) S

Flow Chart:



Examples:

```
UNLESS  (X.NE.Y) U = V+W

UNLESS  (T.LE.0.OR.S.GE.R)
.  I = I+1
.  Z = 0.1
...FIN
```

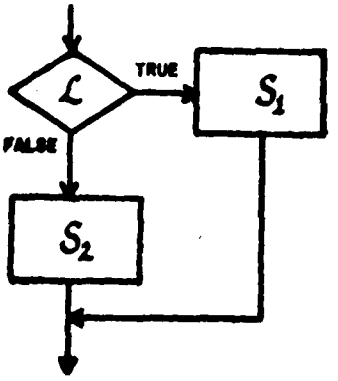
6.1.3 WHEN...ELSE

Description: The WHEN...ELSE statements correspond to the IF...THEN...ELSE statement of Algol, PL/1, Pascal, etc. In LFP, both the WHEN and the ELSE act as structured statements although only the WHEN has a specification. The ELSE statement must immediately follow the scope of the WHEN. The specifier of the WHEN is evaluated and exactly one of the two scopes is executed. The scope of the WHEN statement is executed if the expression is true and the scope of the ELSE statement is executed if the expression is false. In either case, control then passes to the next statement following the ELSE scope.

General Form:

WHEN ($\mathcal{L}$) S_1
ELSE S_2

Flow Chart:



Examples:

```
WHEN (X.EQ.Y) U = V+W
ELSE U = V-W

WHEN (X.EQ.Y)
.  U = V+W
.  T = T+1.5
...FIN
ELSE U = V-W

WHEN (X.EQ.Y) U = V+W
ELSE
.  U = V-W
.  T = T+1.5
...FIN
```

Note: WHEN and ELSE always exist as a pair of statements, never separately. Either the WHEN or the ELSE or both may assume the multi-line form. ELSE is considered to be a control phrase, hence it cannot be placed on the same line as the WHEN. Thus "WHEN ($\mathcal{L}$) S_1 ELSE S_2" is not valid.

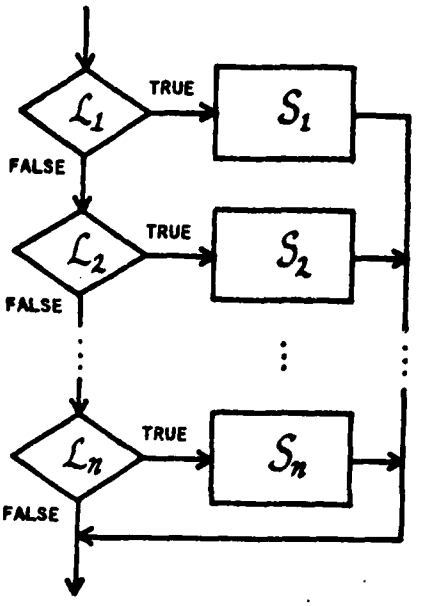
6.1.4 CONDITIONAL

Description: The CONDITIONAL statement is based on the LISP conditional. A list of logical expressions is evaluated one by one until the first expression to be true is encountered. The scope corresponding to that expression is executed, and control then passes to the first statement following the CONDITIONAL. If all expressions are false, no scope is executed. (See, however, the note about OTHERWISE below.)

General Form:

```
CONDITIONAL
. (L1)  S1
. (L2)  S2
.   .    .
.   .    .
.   .    .
. (Ln)  Sn
...FIN
```

Flow Chart:



Examples:

```
CONDITIONAL
. (X.LT.-5.0)  U = U+W
. (X.LE.1.0)   U = U+W+Z
. (X.LE.10.5)  U = U-Z
...FIN
```

```
CONDITIONAL
. (A.EQ.B)     Z = 1.0
. (A.LE.C)
. . Y = 2.0
. . Z = 3.4
. ...FIN
. (A.GT.C.AND.A.LT.B)   Z = 6.2
. (OTHERWISE)   Z = 0.0
...FIN
```

Notes: The CONDITIONAL itself does not possess a one-line form. However, each "(*Ln*) *Sn*" is treated as a structured statement and may be in one-line or multi-line form.

The reserved word OTHERWISE represents a catchall condition. That is, "(OTHERWISE)*Sn*" is equivalent to "(.TRUE.)*Sn*" in a CONDITIONAL statement.

6.1.5 SELECT

Description: The SELECT statement is similar to the CONDITIONAL but is more specialized. It allows an expression to be tested for equality with each expression in a list of expressions. When the first matching expression is encountered, a corresponding scope is executed and the SELECT statement terminates. In the description below $\mathcal{E}_1, \mathcal{E}_2, \ldots, \mathcal{E}_n$ represent arbitrary but compatible expressions. Any type of expression (integer, real, complex,...) is allowed as long as the underlying Fortran system allows such expressions to be compared with an .EQ. OR .NE. operator.

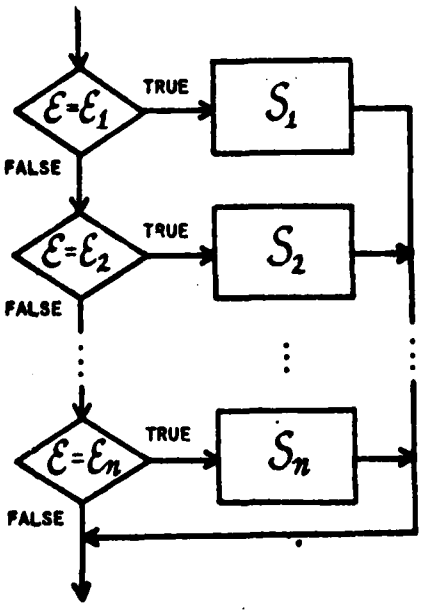
General Form:

SELECT ($\mathcal{E}$)
. ($\mathcal{E}_1$) S_1
. ($\mathcal{E}_2$) S_2
. . . .
. . . .
. . . .
. ($\mathcal{E}_n$) S_n
...FIN

Example:

```
SELECT (OPCODE(PC))
.  (JUMP)  PC = AD
.  (ADD)
.  .  A = A+B
.  .  PC = PC+1
.  ...FIN
.  (SKIP)  PC = PC+2
.  (STOP)  CALL STOPCD
...FIN
```

Flow Chart:



Notes: As in the case of CONDITIONAL, at most one of the S_i; will be executed.

The catchall OTHERWISE may also be used in a SELECT statement. Thus "(OTHERWISE) S_n" is equivalent to "($\mathcal{E}$) S_n" within a "SELECT ($\mathcal{E}$)" statement.

The expression is reevaluated for each comparison in the list, thus lengthy, time consuming, or irreproducable expressions should be precomputed, assigned to a variable, and the variable used in the specification portion of the SELECT statement.

6.2 LOOP Structures

The structured statements described below all have a scope which is executed a variable number of times depending on specified conditions.

Of the five loops presented, the most useful are the DO, WHILE, AND REPEAT UNTIL loops. To avoid confusion, the REPEAT WHILE and UNTIL loops should be ignored initially.

6.2.1 DO

Description: The LFPs DO loop is functionally identical to the Fortran DO loop. The only differences are syntactic. In the LFP DO loop, the statement number is omitted from the DO statement, the incrementation parameters are enclosed in parentheses, and the scope is indicated by either the one line or multi-line convention. Since the semantics of the Fortran DO statement vary from one Fortran compiler to another, a flowchart cannot be given. The symbol $\mathcal{I}$ represents any legal incrementation specification.

General Form

DO ($\mathcal{I}$) S

Examples:

```
DO (I = 1,N)  A(I) = 0.0

DO (J = 3,K,3)
.  B(J) = B(J-1)*B(J-2)
.  C(J) = SIN(B(J))
...FIN
```

6.2.2 WHILE

Description: The WHILE loop causes its scope to be repeatedly executed while a specified condition is true. The condition is checked prior to the first execution of the scope, thus if the condition is initially false the scope will not be executed at all.

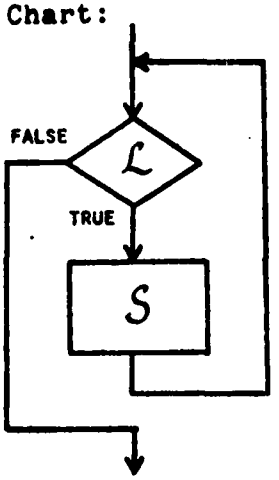
General Form:

WHILE (*L*) *S*

Examples:

```
WHILE (X.LT.A(I)) I = I+1

WHILE (P.NE.0)
.  VAL(P) = VAL(P)+1
.  P = LINK(P)
...FIN
```

Flow Chart:



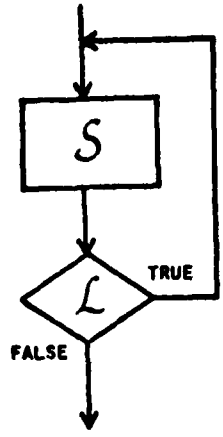
6.2.3 REPEAT WHILE

Description: By using the REPEAT verb, the test is logically moved to the end of the loop. The REPEAT WHILE loop caused its scope to be repeatedly executed while a specified condition remains true. The condition is not checked until after the first execution of the scope. Thus the scope will always be executed at least once and the condition indicates under what circumstances the scope is to be repeated.

Note: "REPEAT WHILE (*L*)" is functionally equivalent to "REPEAT UNTIL (.NOT.(*L*))".

General Form:

REPEAT WHILE (*L*) *S*



Examples:

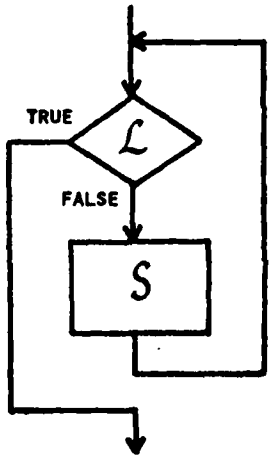
```
REPEAT WHILE(N.EQ.M(I)) I = I+1

REPEAT WHILE (LINK(Q).NE.0)
.  R = LINK(Q)
.  LINK(Q)
.  P = Q
.  Q = R
...FIN
```

6.2.4 UNTIL

Description: The UNTIL loop causes its scope to be repeatedly executed until a specified condition becomes true. The condition is checked prior to the first execution of the scope, thus if the condition is initially true, the scope will not be executed at all. Note that "UNTIL (*L*)" is functionally equivalent to "WHILE (.NOT.(*L*)".

General Form:

UNTIL (*L*) *S*



Examples:

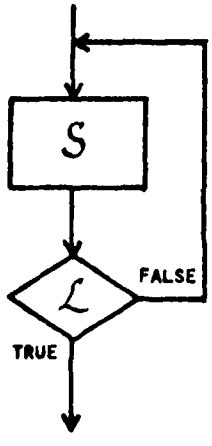
```
UNTIL (X.EQ.A(I))  I = I+1

UNTIL (P.EQ.0)
.  VAL(P) = VAL(P)+1
.  P = LINK(P)
...FIN
```

6.2.5 REPEAT UNTIL

Description: By using the REPEAT verb, the test is logically moved to the end of the loop. The REPEAT UNTIL loop causes its scope to be repeatedly executed until a specified condition becomes true. The condition is not checked until after the first execution of the scope. Thus the scope will always be executed at least once and the condition indicates under what circumstances the repetition of the scope is to be terminated.

General Form:

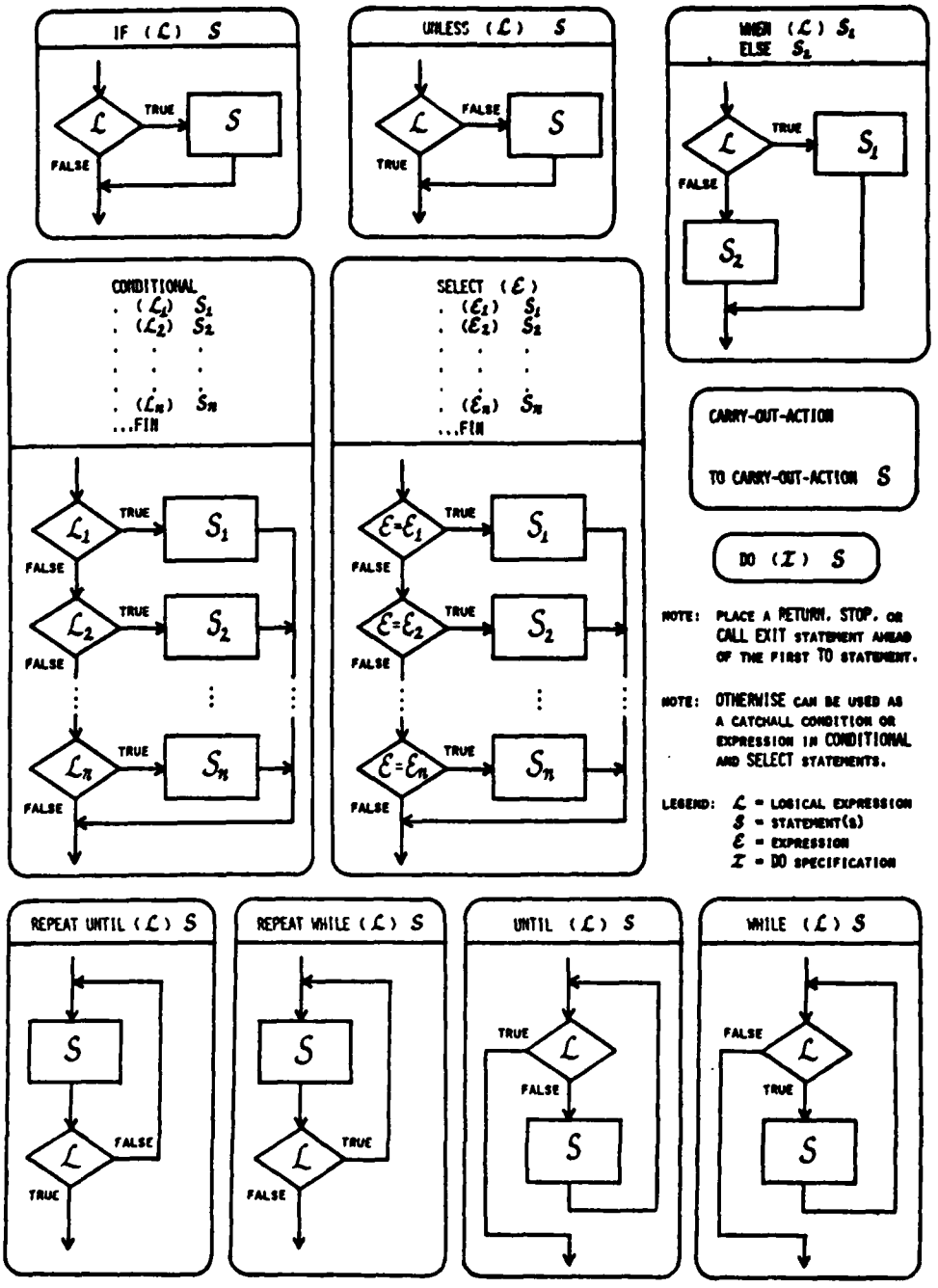
REPEAT UNTIL (*L*) *S*



Examples:

```
REPEAT UNTIL (N.EQ.M(I)) I = I+1

REPEAT UNTIL (LINK(Q).EQ.0)
.  R = LINK(Q)
.  LINK(Q) = P
.  P = Q
.  Q = R
...FIN
```

6.3 LFP Control Structure Summary Sheet



7.0 INTERNAL PROCEDURES

In LFP a sequence of statements may be declared an internal procedure and given a name. The procedure may then be invoked from any point in the program by simply giving its name.

Procedure names may be any string of letters, digits, and hyphens (i.e., minus signs) beginning with a letter and containing at least one hyphen. Imbedded blanks are not allowed. The only restriction on the length of a name is that it may not be continued onto a second line.

Examples of valid internal procedure names:

```
INITIALIZE-ARRAYS
GIVE-WARNING
SORT-INTO-DESENDING-ORDER
INITIATE-PHASE-3
```

A procedure declaration consists of the keyword "TO" followed by the procedure name and its scope. The set of statements comprising the procedure is called its scope. If the scope consists of a single simple statement it may be placed on the same line as the "TO" and procedure name, otherwise the statements of the scope are placed on the following lines and terminated with a FIN statement. These rules are analogous with the rules for forming the scope of a structured statement.

General Form of procedure declaration:

```
TO procedure-name
```

Examples of procedure declarations:

```
TO  RESET-POINTER  P = 0

TO  DO-NOTHING

TO SUMMARIZE-FILE
.  INITIALIZE-SUMMARY
.  OPEN-FILE
.  REPEAT UNTIL (EOF)
.  . ATTEMPT-TO-READ-RECORD
.  . WHEN (EOF)  CLOSE-FILE
.  . ELSE  UPDATE-SUMMARY
.  ...FIN
.  OUTPUT-SUMMARY
...FIN
```

An internal procedure reference is a procedure name appearing where an executable statement would be expected. In fact, an internal procedure reference is an executable simple statement and thus may be used in the scope of a structured statement as in the last example above. When control reaches a procedure reference during execution of a LFP program, a return address is saved and control is transferred to the first statement in the scope of the procedure. When control reaches the end of the scope, control is transferred back to the statement logically following the procedure reference.

A typical LFP program or subprogram consists of a sequence of Fortran declarations: (e.g., INTEGER, DIMENSION, COMMON, etc.) followed by a sequence of executable statements called the body of the program followed by the LFP internal procedure declarations, if any, and finally the END statement.

Here is a complete (but uninteresting) LFP program which illustrates the placement of the procedure declarations.

```
11/13/78  M.I.T. LINCOLN LABORATORY FORTRAN PREPROCESSOR     LPP  02.01
10:07:33                                                    PAGE     1

      %WIDTH 72                                                  PRO00010
            ;INTERACTIVE PROGRAM FOR PDP-10                      PRO00020
            ;TO COMPUTE THE SQUARE ROOT OF X.                    PRO00030
            ;STOP WHEN X IS NEGATIVE.                            PRO00040
                                                                 PRO00050
00001       REAL X,SQRTX                                         PRO00060
00002       REPEAT UNTIL ( X .LT. 0.0)                           PRO00070
00004       .  READ-IN-A-VALUE-OF-X                              PRO00080
00006       .  IF (X .GE. 0.0);ONLY WHEN X IS POSITIVE           PRO00090
00007       .  .  COMPUTE-SQRT-OF-X                              PRO00100
00009       .  .  TYPE-OUT-THE-RESULT;BOTH X AND SQRTX           PRO00110
00011       .  ...FIN                                            PRO00120
00012       ...FIN                                               PRO00130
00013       STOP;HALT EXECUTION                                  PRO00140

      ----------------------------------------

00014       TO READ-IN-A-VALUE-OF-X                              PRO00150
00015       .  TYPE 10                                           PRO00160
00016    10 .  FORMAT(' X = ',$)                                 PRO00170
00017       .  ACCEPT 20,X                                       PRO00180
00018    20 .  FORMAT(F);FREE FORMAT INPUT                       PRO00190
00019       ...FIN                                               PRO00200

      ----------------------------------------

00020       TO COMPUTE-SQRT-OF-X   SQRTX=SQRT(X)                 PRO00210

      ----------------------------------------

00023       TO TYPE-OUT-THE-RESULT                               PRO00220
00024       .  TYPE 30,X,SQRTX                                   PRO00230
00025    30 .  FORMAT(' THE SQRT OF ',F7.2,' IS ',F7.2)          PRO00240
00026       ...FIN                                               PRO00250
00030       END                                                  PRO00260

      ----------------------------------------

            PROCEDURE CROSS-REFERENCE TABLE

      00020 COMPUTE-SQRT-OF-X
            00007

      00014 READ-IN-A-VALUE-OF-X
            00004

      00023 TYPE-OUT-THE-RESULT
            00009


      NO DIAGNOSTICS

         26 LPP LINES SCANNED,    30 FORTRAN STATEMENTS GENERATED
```

Notes concerning internal procedures:

1. All internal procedure declarations must be placed at the end of the program just prior to the END statement. The appearance of the first "TO" statement terminates the body of the program. The translator expects to see nothing but procedure declarations from that point on.

2. The order of the declarations is not important. Alphabetical by name is an excellent order for programs with a large number of procedures.

3. Procedure declarations may not be nested. In other words, the scope of a procedure may not contain a procedure declaration. It may of course contain executable procedure references.

4. Any procedure may contain references to any other procedures (excluding itself).

5. Dynamic recursion of procedure referencing is not permitted.

6. All program variables within a main or subprogram are global and are accessable to the statements in all procedures declared within that same main or subprogram.

7. There is no formal mechanism for defining or passing parameters to an internal procedure. When parameter passing is needed, the Fortran function or subroutine subprogram mechanism may be used or the programmer may invent his own parameter passing methods using the global nature of variables over internal procedures.

8. The LFP translator separates procedure declarations on the listing by dashed lines as shown in the preceding example.

9. Internal procedure references called from inside nested DO Loops are not recommended.

8.0 CONTROL STATEMENTS

Statements which supply information to the LFP translator during processing are called control statements. These statements, denoted by a control character in column 1, allow user control over the format (appearance) of the LFP listing and permit the inclusion of the contents of other files in the source.

A control statement, in general, will contain 3 items:

control character	This is a percent sign (%) in column 1. This character may be changed by a CONTROL control statement. See section 8.1.2.
control word	This is a string from 1 to 8 characters in length that denotes the control card type and must not contain imbedded blanks.
argument	This is either a numeric or alphabetic string (optional for some keywords).

The only requirement on the control statement format is that the control word comes before the argument and that they are separated by at least one blank. Otherwise, the control word and argument are typed in a field-free format.

Each control word may be recognized from a subset of the complete control word, e.g., the control word INCLUDE can be recognized by an I, IN,..., or INCLUDE. The minimum recognition pattern is denoted by the capital letters in each control word.

All statements will be listed in the LFP listing except those that follow a NOLIST control. A subsequent LIST control statement will negate the effect of a NOLIST.

Control statements can occur anywhere in the user's LFP source file or in the included files.

8.1 Listing Format Controls

The format control statements control the appearance of the LFP listing such as page width, spacing and page length, etc.

8.1.1 Comment delimiter % COMment char Default ;

This statement defines the comment field delimiter character, which should not be part of the standard Fortran character set for obvious reasons. A comment field may be placed on any LFP source statement including control statements. The delimiter does not have to be separated from the LFP statement by a blank.

Examples:

```
%COM $
%       COMMENT      ; $ change delimiter back to a ;
```

The first example changes the current comment delimiter to a $. Example 2 then changes the delimiter back to a ; (the field "$ change delimiter back to a ;" is treated as a comment).

8.1.2 Control character % Control chars Default %

This control statement allows the user to define a character or a set of characters that will identify a control statement. Caution - Do not use the character C or regular comments will be flagged as BAD CONTROL CARDS.

Unrelated examples:

```
%C  *  ; change control character to a *
%  CON  +-AX
%CONTROL  >;+
```

In example 2 any statement with a +, -, A, or X in column 1 is treated as a control statement. In example 3 the control character is set to >, the field ";+" is an inline comment.

If the argument is not present the default control character is assumed.

8.1.3 Double Spacing % DS

This control statement will initiate double spacing on the LFP listing. Errors are still single spaced. Double spacing is done by carriage control.

8.1.4 Heading % Heading character string

This control statement defines a character string that will print as heading information at the top of each output page of the LFP listing. The string is not delimited by single quotes and may contain imbedded blanks up to a length of 69 characters.

If the heading length is larger than the page width, the heading is truncated on the right.

The default Heading is

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Examples:

```
%H SUBROUTINE RENAME
%HEADING SYSTEM RS2-TEST
%HEAD  INS SIMULATION;MODEL 4
```

In the third example the field ";MODEL 4" is treated as a comment and will not be part of the heading.

8.1.5 Statement Numbering % LABEL XYZ

The LABEL control statement determines the method of statement numbering on the LFP listing. The user is presented with the following choices:

1. Fortran line numbers. These are internally generated by the compiler and are affixed to the listing output to the left of the statements. They are not to be confused with statement labels (found in columns 1 - 5). Fortran line numbers are sequential from card to card, however, some Fortran compilers, e.g., IBM, do not number comments or continuations.

2. LFP line numbers. These are internally generated by LFP and are sequential from statement to statement.

3. Line tags. These are the 8 column identification field found in columns 73 - 80 of the input LFP statements.

In the LFP listing of a sample program in Section 11, the numbers to the left of the statements are Fortran line numbers while those on the right side are line tags. These were chosen by the options available for the XYZ argument field on the LABEL control statement.

Field	Value	Description
X	0	Increment by 1 the Fortran line number for every line of Fortran generated. This corresponds to most CDC and MODCOMP compilers. DEFAULT.
	1	Increment by 1 the Fortran line number for every line of Fortran generated except comments or continuations. This is standard for IBM machines.
Y	0	Put LFP line numbers to the left of the source statements.
	1	Put the Fortran line numbers as determined by the field X to the left of the source. DEFAULT.
Z	0	Put LFP line numbers to the right of the source.
	1	Put the 8 column line tag to the right of the source. DEFAULT.
	2	Have no field to the right of the source.

The sample LFP listing in Section 11 was prepared with the default LABEL control statement.

Examples:

```
%LABEL  111   ; This is the default
%LABEL        ; This resets the default
%LABEL 12     ; X=0,Y=1,Z=2
```

8.1.6 Left Adjust % LAdj

This control statement will left adjust the input source to column 7, i.e., all blanks from column 7 to the first nonblank character of each source statement will be removed. This is particularly useful if the source had been indented on input, because LFP does its own indenting.

8.1.7 # Lines/Page % Line N

This statement specifies the number of printed lines on each page of the LFP listing which includes 3 lines for the heading. Reasonable values for N are between 50 and 60 for a line printer. For a terminal with a roll of paper, N could be made very large which would prevent the top of page headers from being written.

Examples:

```
%L  55
%  LINE 60
```

8.1.8 Listing Control % LIST

This control statement generates the LFP listing. This may be used in conjunction with the %NOLIST control to selectively list portions of the program. Initially the %LIST control is in effect.

8.1.9 No Left Adjust % NOLAdj

This control negates the effect of the LADJ control, i.e., do not left adjust the LFP source. NOLADJ is the default.

8.1.10 No Listing % NOList

The control turns off the generation of the LFP listing. Only the presence of a LIST card will turn the listing back on. A NOLIST statement is printed except if it is the first record processed.

8.1.11 Page Eject % Page N

This control statement forces a page eject on the LFP listing if N is zero or missing. If N is positive, this statement acts as a conditional page eject to keep blocks of the listing contiguous. If there are fewer than N lines left on the page, then eject a page.

If the LFP listing is double or triple spaced (see DS and TS controls) the N means double or triple spaced lines.

Examples:

```
%P
% Page 20
```

8.1.12 Single Spacing % SS

This control will single space the LFP listing, which is the default spacing.

8.1.13 Listing Width % Width N

The width control statement specifies the page width of the LFP listing in characters. This affects all output - including page headers and the procedure cross reference table.

N will usually range from 72 to 133 with 1 column being reserved for carriage control. See the sample LFP listing in Section 11 with a column width of 78. 17 columns are dedicated for statement numbering and labelling leaving N-17 columns for the indented source statements.

Examples:

```
%W 133
%WIDTH 80; set width to 80 columns
```

8.2 Inclusion of External Files

8.2.1 INCLUDE Command % Include FILENAME

The INCLUDE control statement allows the user to include in the source program the contents of other files. This is particularly effective in the usage of common blocks.

For example a series of common definitions are put in a file named COMMON. The user's source program would contain a %INCLUDE COMMON statement to include the common definitions. Included files may not contain nested %INCLUDE statements.

The filename must be a legitimate SED file and may be compressed or uncompressed.

Examples:

```
%I  CBLOCK1
%  INCLUDE  ABLOC
```

If the filename is missing on the INCLUDE card or if the file does not exist, the statement is ignored with diagnostic being issued to the LFP listing and the terminal.

8.2.2 Include Expansion % INCExp N

This control statement controls the expansion of the %INCLUDE file. If N is 1 the file is included, if 0 the file is not included in either the LFP listing or the generated Fortran. Default N=1.

Examples:

```
%INCEXP 0
%  INCE 1
```

8.3 Control Statement Summary

	Section
%COMment X Define the comment delimiter character X. Default is ;	8.1.1
%Control X Define the control character X. Defalut is %	8.1.2
%DS Double space the LFP listing	8.1.3
%Heading CHARACTER STRING Define the heading CHARACTER STRING to go at the top of each page on the LFP listing.	8.1.4
%Include FILENAME Include the contents of the file = FILENAME in the source file. The filetype must be LFP.	8.2.1
%INCExp N Controls the inclusion of a file on the INCLUDE card. if N is 0 the file is not included, if N is 1 the file is included. Default = 1.	8.2.2
%LABEL XYZ X 0 CDC Fortran line numbering 1 IBM Fortran line numbering (default) Y 0 LFP line numbers at left of listing 1 Fortran line numbers at left of listing (default) Z 0 LFP line numbers at right of listing 1 Line tags at right of listing (default) 2 blanks	8.1.5
%LAdj Left adjust the source to column 7, removing blanks.	8.1.6
%Line N Print N lines per page. Default = 60.	8.1.7
%List Print LFP listing. Default.	8.1.8
%NOLadj Do not left adjust source to column 7 (default).	8.1.9
%NOList Turn off LFP listing.	8.1.10
%Page N Eject a page if N=0 or N is missing. Eject a page if there are less than N lines left on a page.	8.1.11
%SS Single space LFP listing (default).	8.1.12
%Width N Width of LFP output listing in characters. Default = 133	8.1.13

8.4 Control Statement Example - Typical Program Setup.

The following control statements at the beginning of each source program generate a listing that greatly facilitates referencing.

```
%NOLIST
%HEADING SUBROUTINE NAME
%PAGE
%WIDTH 110
%LIST
     SUBROUTINE NAME
     .
     .
     .
     .
     END

%NOLIST
%HEADING SUBROUTINE N2
%PAGE
%WIDTH 110
%LIST
     SUBROUTINE N2
     .
     .
     .
     END
```

9.0 COMMENTS

Comments in LFP are recognized by the presence of a specified comment delimiter in any column or by the traditional method of the character "C" in column 1. All characters to the right of and including the delimiter are considered the comment field.

Comments can be isolated, that is, the source statement is only a comment, or they can be inline, meaning a statement and a comment field may be present on the same source line.

All source lines of LFP including control statements may contain inline comments. There does not have to be a blank between the last character of the statement and the comment delimiter.

Isolated comments are indented to the current LFP listing level if columns 2-6 of the statement are blank. An inline comment is indented only if the statement is indented.

Inline comment fields are stripped off the input statements before the Fortran output is produced. No comments are sent to the generated Fortran.

Examples:

```
C     NORMAL COMMENT
C THIS COMMENT WILL NOT BE INDENTED
;     THE SEMICOLON IS THE DEFAULT DELIMETER
          ; THE DELIMETER MAY BE IN ANY COLUMN
      A = SORT(B*B+C*C); COMPUTE RADIUS OF CIRCLE
%COMMENT $  ; CHANGE DELIMETER TO  A  $
      DETERMINE-NEXT-EVENT$BY A TABLE LOOKUP
```

10.0 LFP RESTRICTIONS AND NOTES

If LFP were implemented by a nice intelligent compiler this section would be much shorter. Thus the LFP programmer must observe the following restrictions.

1. LFP must invent many statement numbers in creating the Fortran program. It does so by beginning with a large number (usually 99999) and generating successively smaller numbers as it needs them. Do not use a number which will be generated by the translator. A good rule of thumb is to avoid using 5 digit statement numbers.

2. The LFP translator must generate integer variable names. It does so by using names of the form "Innnnn" when nnnnn is a 5 digit number related to a generated statement number. Do not use variables of the form Innnnn and avoid causing them to be declared other than INTEGER. For example the declaration "IMPLICIT REAL (A-Z)" leads to trouble. Try "IMPLICIT REAL (A-H, J-Z) instead.

3. The translator does not recognize continuation lines in the source file. Thus Fortran statements may be continued since the statement and its continuations will be passed through the translator without alteration. (See chapter 2.) However, an extended LFP statement which requires translation may not be continued. The reasons one might wish to continue a LFP statement are 1) It is a structured statement or procedure declaration with a one statement scope too long to fit on a line, or 2) it contains an excessively long specification portion or 3) both of the above. Problem 1) can be avoided by going to the multiline form. Frequently problem 2) can be avoided when the specification is an expression (logical or otherwise) by assigning the expression to a variable in a preceding statement and then using the variable as the specification. Avoid continued IF statements.

4. Blanks are meaningful separators in LFP statements: don't put them in dumb places like the middle of identifiers or key words and do use them to separate distinct words like REPEAT and UNTIL.

5. Let LFP indent the listing. Start all statements in col. 7 and the listing will always reveal the true structure of the program (as understood by the translator, of course). The control statement %LADJ allows for preindented source code.

6. As far as the translator is concerned, FORMAT statements are executable Fortran statements since it doesn't recognize them as extended LFP statements. Thus, only place FORMAT statements where an executable Fortran statement would be acceptable. Don't put them between the end of a WHEN statement and the beginning of an ELSE statement. Don't put them between procedure declarations.

Incorrect Examples:

```
    WHEN (FLAG)  WRITE(3,30)
30  FORMAT(7H TITLE:)
    ELSE  LINE = LINE+1
```

```
    TO WRITE-HEADER
    .  PAGE = PAGE+1
    .  WRITE(3,40) H,PAGE
    ...FIN
40  FORMAT (70A1,I3)
```

Corrected Examples:

```
    WHEN (FLAG)
    .  WRITE(3,30)
30  .  FORMAT(7H TITLE:)
    ...FIN
    ELSE  LINE = LINE+1
```

```
    TO WRITE-HEADER
    .  PAGE = PAGE+1
    .  WRITE(3,40) H, PAGE
40  .  FORMAT(70A1,I3)
    ...FIN
```

7. The translator, being simple-minded, recognizes extended LFP statements by the process of scanning the first identifier on the line. If the identifier is one of the LFP keywords IF, WHEN, UNLESS, FIN, etc., the line is assumed to be a LFP statement and is treated as such. Thus, the LFP keywords are reserved and may not be used as variable names. In case of necessity, a variable name, say WHEN, may be slipped past the translator by embedding a blank within it. Thus "WH EN" will look like "WH" followed by "EN" to the translator which is blank sensitive, but line "WHEN" to the compiler which ignores blanks.

8. In scanning a parenthesized specification, the translator scans from left to right to find the parenthesis which matches the initial left parenthesis of the specification. The translator, however, is ignorant of Fortran syntax including the concept of Hollerith constants and will treat Hollerith parenthesis as syntactic parenthesis. Thus, avoid placing Hollerith constants containing unbalanced parenthesis within specifications. If necessary, assign such constants to a variable, using a DATA or assignment statement, and place the variable in the specification.

Incorrect Example:	Corrected Example:
`IF (J.EQ.'(')`	`LP = '('` `IF(J.EQ.LP)`

9. The LFP translator will not supply the statements necessary to cause appropriate termination of main and sub-programs. Thus it is necessary to include the appropriate RETURN, STOP, or CALL EXIT statement prior to the first internal procedure declaration. Failure to do so will result in control entering the scope of the first procedure after leaving the body of the program. Do not place such statements between the procedure declarations and the END statement.

10. The LFP translator ignores blank lines and does not pass comments or blank lines on to the compiler. Thus blank lines can be used for program clarity without worry.

11. Some FORTRAN compilers allow branching in and out of DO LOOPS-other compilers prohibit this. The usage of internal procedure references inside DO structures is not recommended.

11.0 EXAMPLE OF LFP LISTING

The user's program is named QDROOT LFP whose source is listed in Figure 11-2.

Figure 11-1 is the resulting LFP listing. Note the correlation between the line numbers on the left of the LFP listing with the lines on the Fortran compiler output (Figure 11-3). This is accomplished by the default LABEL control card (Section 8.1.5).

```
03/02/81     SUBROUTINE QDROOT     SOLVE QUADRATIC FORMULA     LFP  02.01
12:41:37                                                       PAGE     1

00001 %LIST                                                          QDRTS005
00001       SUBROUTINE QDROOT(A,B,C,X1,X2,IERR)                      . 2MAR1
00002                                                                QDRTS007
00002       REAL*8 A,B,C,X1,X2,DISCRM,TERM1,TERM2                    QDRTS008
00003                                                                QDRTS009
00003       ;SOLVE QUADRATIC EQUATION .... A*X*X + B*X + C = 0       QDRTS010
00003       ;FOR REAL X1 AND X2.                                     . 2MAR1
00003       ;IERR  ERROR CODE                                        . 2MAR1
00003       ;       -2     A AND B ARE 0.0---NO ROOTS                . 2MAR1
00003       ;       -1     DISCRIMINANT < = 0.0---IMAGINARY ROOTS    . 2MAR1
00003       ;        0     NORMAL RETURN---2 REAL ROOTS              . 2MAR1
00003       ;        1     A IS 0.0---1 REAL ROOT                    . 2MAR1
00003                                                                QDRTS014
00003       IERR=0                                                   QDRTS015
00004       WHEN (A .NE. 0.0D0)                                      QDRTS016
00005       . DISCRM=B*B-4.0D0*A*C;  CALCULATE THE DISCRIMINANT      QDRTS017
00006       . WHEN (DISCRM .LT. 0.0D0)                               . 2MAR1
00007       . . IERR=-1;      SET NEGATIVE DISCRIMINANT CODE         . 2MAR1
00008       . . WRITE(6,10) A,B,C,DISCRM                             QDRTS020
00009    10 . . FORMAT(' RTN QDROOT, DISCRIM   0 ',/,                . 2MAR1
00010      +. .   '     A,B,C,DISCRIM =,',4E17.6)                    . 2MAR1
00011       . . X1=0.0D0                                             QDRTS022
00012       . . X2=0.0D0                                             QDRTS023
00013       . ...FIN                                                 QDRTS024
00014       . ELSE                                                   QDRTS025
00014       . . TERM1=-B/(2.0D0*A)                                   QDRTS026
00015       . . TERM2=DSQRT(DISCRM)/(2.0D0*A)                        QDRTS027
00016       . . X1=TERM1+TERM2;      CALCULATE ROOTS X1 and X2       QDRTS028
00017       . . X2=TERM1 -TERM2                                      QDRTS029
00018       . ...FIN                                                 QDRTS030
00018       ...FIN                                                   QDRTS031
00019       ELSE;     THE HIGH ORDER COEFFICIENT IS ZERO             QDRTS032
00019       . WHEN (B.NE.0.0D0)                                      . 2MAR1
00020       . . X1=-C/B                                              QDRTS033
00021       . . X2=X1                                                QDRTS034
00022       . . IERR=1                                               . 2MAR1
00023       . ...FIN                                                 . 2MAR1
00024       . ELSE; A AND B ARE BOTH 0.0                             . 2MAR1
00024       . . X1=0.0D0                                             . 2MAR1
00025       . . X2=0.0D0                                             . 2MAR1
00026       . . IERR=-2                                              . 2MAR1
00027       . ...FIN; ELSE                                           . 2MAR1
00027       ...FIN                                                   QDRTS036
00028       RETURN                                                   QDRTS037
00029       END                                                      QDRTS038

    NO DIAGNOSTICS
      49 LFP LINES SCANNED,     29 FORTRAN STATEMENTS GENERATED
$$
$$
LIS
```

Fig. 11-1. LFP listing of user's program.

```
*D2* MC/LBL/LL SOURCE EDITOR  DATE 03/02/81  12:41:59            Page 1

 1   %NOLIST                                                    QDRTS001
 2   %HEAD SUBROUTINE QDROOT     SOLVE QUADRATIC FORMULA        . 2MAR1
 3   %WIDTH 80                                                  . 2MAR1
 4   %PAGE                                                      QDRTS004
 5   %LIST                                                      QDRTS005
 6        SUBROUTINE QDROOT(A,B,C,X1,X2,IERR)                   . 2MAR1
 7                                                              QDRTS007
 8        REAL*8 A,B,C,X1,X2,DISCRM,TERM1,TERM2                 QDRTS008
 9                                                              QDRTS009
10        ;SOLVE QUADRATIC EQUATION .... A*X*X + B*X + C = 0    QDRTS010
11        ;FOR REAL X1 AND X2.                                  . 2MAR1
12        ;IERR   ERROR CODE                                    . 2MAR1
13        ;        -2     A AND B ARE 0.0---NO ROOTS            . 2MAR1
14        ;        -1     DISCRIMINANT   = 0.0 ---IMAGINARY ROOTS . 2MAR1
15        ;         0     NORMAL RETURN---2 REAL ROOTS          . 2MAR1
16        ;         1     A IS 0.0---1 REAL ROOT                . 2MAR1
17                                                              QDRTS014
18        IERR=0                                                QDRTS015
19        WHEN (A .NE. 0.0D0)                                   QDRTS016
20        DISCRM=B*B-4.0D0*A*C;     CALCULATE THE DISCRIMINANT  QDRTS017
21        WHEN (DISCRM .LT. 0.0D0)                              . 2MAR1
22        IERR=-1;      SET NEGATIVE DISCRIMINANT CODE          . 2MAR1
23        WRITE(6,10) A,B,C,DISCRM                              QDRTS020
24     10 FORMAT(' RTN QDROOT, DISCRIM    0 ',/,                . 2MAR1
25       + '     A,B,C,DISCRIM =,',4E17.6)                     . 2MAR1
26        X1=0.0D0                                              QDRTS022
27        X2=0.0D0                                              QDRTS023
28        FIN                                                   QDRTS024
29        ELSE                                                  QDRTS025
30        TERM1=-B/(2.0D0*A)                                    QDRTS026
31        TERM2=DSQRT(DISCRM)/(2.0D0*A)                         QDRTS027
32        X1=TERM1+TERM2;     CALCULATE ROOTS X1 AND X2         QDRTS028
33        X2=TERM1-TERM2                                        QDRTS029
34        FIN                                                   QDRTS030
35        FIN                                                   QDRTS031
36        ELSE;     THE HIGH ORDER COEFFICIENT IS ZERO          QDRTS032
37        WHEN (B.NE.0.0D0)                                     . 2MAR1
38        X1=-C/B                                               QDRTS033
39        X2=X1                                                 QDRTS034
40        IERR=1                                                . 2MAR1
41        FIN                                                   . 2MAR1
42        ELSE; A AND B ARE BOTH 0.0                            . 2MAR1
43        X1=0.0D0                                              . 2MAR1
44        X2=0.0D0                                              . 2MAR1
45        IERR=-2                                               . 2MAR1
46        FIN; ELSE                                             . 2MAR1
47        FIN                                                   QDRTS036
48        RETURN                                                QDRTS037
49        END                                                   QDRTS038
TOTAL RECORDS WRITTEN =     50
$$
EXIT
$$
$EXE FR4,,LO,NOMAP
```

Fig. 11-2. User's source program.

```
IV FORTRAN IV     C.0              03-02-81   12:42 PAGE 1

    1        SUBROUTINE QDROOT(A,B,C,X1,X2,IERR)                . 2MAR1
    2        REAL*8 A,B,C,X1,X2,DISCRM,TERM1,TERM2              QDRTS008
    3        IERR=0                                             QDRTS015
    4        IF(.NOT.(A .NE. 0.0D0)) GO TO 99998                QDRTS016
    5        DISCRM=B*B-4.0D0*A*C                               QDRTS017
    6        IF(.NOT.(DISCRM .LT. 0.0D0)) GO TO 99996           . 2MAR1
    7        IERR=-1                                            . 2MAR1
    8        WRITE(6,10) A,B,C,DISCRM                           QDRTS020
    9     10 FORMAT(' RTN QDROOT, DISCRIM    0',/,              . 2MAR1
   10       + '     A,B,C,DISCRIM =,',4E17.6)                  . 2MAR1
   11        X1=0.0D0                                           QDRTS022
   12        X2=0.0D0                                           QDRTS023
   13        GO TO 99997                                        QDRTS024
   14 99996 TERM1=-B/(2.0D0*A)                                  QDRTS026
   15        TERM2=DSQRT(DISCRM)/(2.0D0*A)                      QDRTS027
   16        X1=TERM1+TERM2                                     QDRTS028
   17        X2=TERM1-TERM2                                     QDRTS029
   18 99997 GO TO 99999                                         QDRTS031
   19 99998 IF(.NOT.(B.NE.0.0D0)) GO TO 99994                   . 2MAR1
   20        X1=C/B                                             QDRTS033
   21        X2=X1                                              QDRTS034
   22        IERR=1                                             . 2MAR1
   23        GO TO 99995                                        . 2MAR1
   24 99994 X1=0.0D0                                            . 2MAR1
   25        X2=0.0D0                                           . 2MAR1
   26        IERR=-2                                            . 2MAR1
   27 99995 CONTINUE                                            QDRTS036
   28 99999 RETURN                                              QDRTS037
   29        END                                                QDRTS038

$$
```

Fig. 11-3. FORTRAN listing of user's program.

12.0 ERRORS

This section provides a framework for understanding the error handling mechanisms of version 02.01 of the LFP preprocessor. The system described below is at an early point in evolution, but has proven to be quite workable. After each execution of LFP the message NO DIAGNOSTICS is sent to the terminal and the listing if there were no errors. If there were errors the message ERRORS - MAJOR xxxxx, MINOR yyyyy, CONTROL CARDS zzzzz is printed.

The LFP translator examines a LFP program on a line by line basis. As each line is encountered it is first subjected to a limited syntax analysis followed by a context analysis. Errors may be detected during either of these analyses. It is also possible for errors to go undetected by the translator.

12.1 Syntax Errors

The fact that a statement has been ignored may, of course, cause some context errors in later statements. For example the control phrase "WHEN (X(I).LT.(3+4)" has a missing right parenthesis. This statement will be ignored, causing as a minimum the following ELSE to be out of context. The programmer should of course be aware of such effects. More is said about them in the next section.

12.2 Context Errors

If a statement successfully passes the syntax analysis, it is checked to see if it is in the appropriate context within the program. For example, an ELSE must appear following a WHEN and nowhere else. If an ELSE does not appear at the appropriate point or if it appears at some other point, then a context error has occurred. A frequent source of context errors in the initial stages of development of a program comes from miscounting the number of FIN's needed at some point in the program.

With the exception of excess FIN's which do not match any preceding control phrase and are ignored (as indicated by overprinting the line number), all context errors are treated with a uniform strategy. When an out-of-context source statement is encountered, the translator generates a "STATEMENT(S) NEEDED" message. It then invents and processes a sequence of statements which, if they had been included at that point in the program, would have placed the original source statement in a correct context. A message is given for each such statement invented. The original source statement is then processed in the newly created context.

By inventing statements the translator is not trying to patch up the program so that it will run correctly, it is simply trying to adjust the local context so that the original source statement and the statements which follow will be acceptable on a context basis. As in the case of context errors generated by ignoring a syntactically incorrect statement, such an adjustment of context frequently causes further context errors later on. This is called propagation of context errors.

12.3 Undetected Errors

The LFP translator is ignorant of most details of Fortran syntax. Therefore most Fortran syntax errors will be detected by the Fortran compiler and not the LFP translator. In addition, there are two major classes of LFP errors which will be caught by the compiler and not the translator.

The first class of undetected errors involves misspelled LFP keywords. A misspelled keyword will not be recognized by the translator. The line on which it occurs will be assumed to be a Fortran statement and will be passed unaltered to the compiler which will undoubtably object to it. A common error, for example, is to spell UNTIL with two L's. Such statements are passed to the compiler, which then produces an error message. The fact that an intended control phrase was not recognized frequently causes a later context error since a level of indentation will not be triggered.

The second class of undetected errors involves unbalanced parentheses. (See also note 8 in Section 10.0). When scanning a parenthesized specification, the translator is looking for a matching right parenthesis. If the matching parenthesis is encountered before the end of the line the remainder of the line is scanned. If the remainder is blank or consists of a recognizable internal procedure reference, all is well. If neither of the above two cases hold, the remainder of the line is assumed (without checking) to be a simple Fortran statement which is passed to the Compiler. Quite often this assumption may be wrong. Thus the statement

```
"WHEN (X.LT.A(I)+Z))  X = 0"
```

is broken down into

```
keyword "WHEN"
specification "(X.LT.A(I)+Z)"
Fortran statement ")  X = 0"
```

Needless to say, the compiler will object to ") X = 0" as a statement.

Programmers on batch oriented systems have less difficulty with undetected errors due to the practice of running the program through both the translator and the compiler each time a run is submitted. The compiler errors usually point out any errors undetected by the translator.

Programmers on timesharing systems tend to have a bit more difficulty since an undetected error in one line may trigger a context error in a much later line. Noticing the context error, the programmer does not proceed with compilation and hence is not warned by the compiler of the genuine cause of the error. One indication of the true source of the error may be an indentation failure at the corresponding point in the listing.

LFP ERROR LIST

```
END statement is missing
Translator has used up allotted space for tables
CONDITIONAL or SELECT apparently missing
ELSE necessary to match FIN
FIN necessary to match line #
no control phrase for FIN to match
only TO and END are valid at this point
WHEN to match following ELSE
procedure already defined
procedure invoked but not defined
invalid character in statement label field
recognizable statement followed by garbage
left parenthesis does not follow keyword
missing a right parenthesis
valid procedure name does not follow TO
```

12.4 Control Card Errors

There are 4 control card error messages.

1. BAD INCLUDE FILENAME = XXXXXXXX

   This indicates that the filename XXXXXXXX is not found. The include card is ignored.

   Reasons - misspelled filename
   - wrong USL assignment
   - device not USL

2. RECURSIVE INCLUDE DECKS NOT ALLOWED

   An include deck cannot include itself. The include card is ignored.

3. INCLUDES NESTED LEVEL GREATER THAN 1

4. BAD CONTROL CARD

   This catchall error indicates something was wrong with the control card.

   Possible reasons
   - misspelled control word
   - forgot control word
   - no argument present when one has needed
   - bad argument type
   - bad argument

   This error results in an ignored control card.

This error message is sent to the LFP listing and also to the terminal. The LFP line number (see 8.1.5 under LABEL control) is affixed to the error prior to printing at the terminal.

13.0 PROCEDURE FOR USAGE ON MODCOMP

The procedure to execute LFP is called $LPG , which also performs the FORTRAN compilation, assembly and the saving of the binary in a user library. To execute $LPG type the following job control:

```
$JOB
$LPG FN USL LO UL
```

where

FN Filename of file to be processed by LFP. This may be in compressed or noncompressed ASCII.

USL User source library which contains the file FN. The default is SU.

LO The listing output is sent to this device (default is VP) which is the Versatek line printer.

UL The binary is saved in this sequential utility library. The default is SS. If the paraform specified is BO, the binary is not saved but left on device BO.

The listing of the procedure $LPG is in Figure 13-1.

If any files are to be included (see Section 8.2) and they are not in the USL specified by paraform #2, the assignment

```
$ASS II USL2
```

must be made to the appropriate USL before invoking $LPG.

```
*D2 MC/LBL/LL SOURCE EDITOR  DATE 02/19/81  11:19:11


      1.  $PRODEFAULT LPG,%1,SU,VP,SS,NOLO,NOMAP
      2.  $NOP PROCEDURE TO EXECUTE LFP, FORTRAN, ASSEMBLER AND LIB
      3.  $POS %1,%2
      4.  $IF %3=VP,3
      5.  $IF %3=NO,2
      6.  $IF %3=LO,1
      7.  $AVR CI 16
      8.  $ASS LO=%3
      9.  $EXE LFP
     10.  $ASS SI=SC
     11.  $EXE FR4,,%5,%6
     12.  $WEOF SO
     13.  $ASS SI SO
     14.  $REW SI SO
     15.  $EXE M4A,,NOLO,NOSC
     16.  $WEOF BO
     17.  $IF %4=BO,4
     18.  $REW BO
     19.  $ASS BI=BO
     20.  $IFM %1 , PRO  $LET %1=MAIN
     21.  $DO SUB,%1,%4
     22.  $NOTE LPG DONE ---
     23.  $AVR CI
     24.  $NOTE --  ILLEGAL LO FILE..MUST BE VP,LO,NO --
TOTAL RECORDS WRITTEN =  25

$$
```

Fig. 13-1. Listing of procedure $LPG.

14.0 Programmer's Guide To LFP.

14.1 Subroutine Description.

LFP consists of a large main program (1800 lines) and approximately 30 subroutines (4200 lines). The purpose of each subroutine is listed below.

Name	Function
BLNKUT	Converts any leading zeroes in a character string to spaces
CATNUM	Convert a number to a character string
CATSTR	Concatenate 2 character strings
CATSUB	Concatenate a character string to a character substring
CHTYP	Classify a character to type
CLOSEF	Write # of diagnostics to terminal and listing and close files.
CMRDSP	Read records from a specified file sequentially in compressed ASCII. This permits the file inclusion feature (Assembler)
CMR4NW	Modified version of compressed read to pad a character string with blanks on input. (Assembler)
CONTOP	Controls the paging in the LFP listing
CPYSTR	Copy a character string
CPYSUB	Copy a character substring
GET	Processes control statements and inline comments
GETC	Get a specified character from a character string

GETCH	Get a specified character from a computer word
GETL	Read the next line of LFP from the mainstream or from an included file
GETTOK	Get a token
HASH	Compute Hash function
INIT	Initialization
LADJ	Remove any blanks in a source statement between column 7 and the first nonblank character
LFP	Main program
LFPSP1	Assembler versions of GETCH, PUTCH and CHTYP
LFPSP2	Assembler versions of PUTC, GETC, CPYSTR, CATSUB, CATNUM, STREQ and CATSTR
LFPSP3	Assembler versions of TRIM and PUTNUM
LITNUM	Convert a numeric character string to binary
NEWNO	Generate the next sequential statement label
OPENF	File initialization
PUT	Generate the FORTRAN, LFP listing and the error output
PUTC	Replace a character in a character string
PUTCH	Replace a character in a computer word
PUTL	Write 1 line to the FORTRAN, LFP listing or error file
PUTNUM	Put a 5 digit number at the beginning of a character string

STREQ	Logical character string compare
STRLT	Logical character string compare
TIMES	Read Modcomp date and time of day
TPAGE	Generate top of page header on the LFP listing
TRIM	Truncate trailing blanks from a character string
$LPG	Procedure to run LFP. (Job control)
$LFPT	Procedure to link edit LFP (Job control)

Unless specified otherwise the above routines are written in LFP.

14.2 Installation of a New LFP Version.

14.2.1 Bootstrapping LFP.

The tape that is supplied has 3 files which contain the following:

File #1 USL copy of the routines listed in section 14.1. This contains the LFP preprocessor written in LFP, assembler language equivalents, a procedure to execute LFP, and a procedure to link edit LFP.

File #2 Fortran equivalents of File #1 (non commented). These files were obtained by running File #1 through LFP.

File #3 TOC Module of LFP

To bring up a version of LFP all that is necessary is to load the module in file 3 and the procedure $LPG in file 1 and attempt execution. Scratch partitions referenced in the procedure may have to be changed.

If the module does not execute, load the FORTRAN equivalents from File #2 (making a minimal amount of changes), compile them under Integer #4 option, and link edit LFP.

The usual test for the correct functioning of LFP is to compare some of the routines in file 2 with the same routines in file 1 processed by the new LFP version.

14.2.2 Installation parameter defaults

The user may wish to change certain default parameters in LFP depending on the computer system characteristics. It is recommended, however, that changes be made to the source version written in LFP--not the Fortran version and that the equivalent Fortran of each LFP version be archived. The following changes may be made:

14.2.2.1 # of print lines/page

In subroutine INIT this is variable LNPPG which is currently set to 50.

14.2.2.2 # of columns/page (width)

In Subroutine INIT this is variable LWIDTH which is currently set to 133. When subroutine GET processes a faulty WIDTH control statement LWIDTH is set to 133.

14.2.2.3 Default Heading

Subroutine INIT contains a data statement for the variable HDRDEF which defines the default heading.

14.2.2.4 LFP Version Number

Subroutine TPAGE contains a data statement for the variable VERSN to define the version #.

14.2.2.5 Default Control Character

Subroutine INIT defines the default control character. To change the default control character to an asterisk add the following code.

```
INTEGER STAR
:
STAR=42 ; HEX 2A
```

Replace the 2 lines

```
CALL PUTC (1, CNTRCH, PCNTC)
SVCNTC=PCNTC
```

with

```
CALL PUTC (1, CNTRCH, STAR)
SVCNTC=STAR
```

When subroutine GET processes a faulty CONTROL card, the percent sign is restored as a control character.

14.2.2.6 Default Statement Labelling/Counting

In subroutine INIT variable IBMMET controls the statement counting;

IBMMET=0 # all generated FORTRAN statements sequentially

IBMMET=1 # all generated FORTRAN statements sequentially except comments or continuation records.

Variable STNUML controls the line # at the left of the listing:

STNUML=0 Use the LFP line # (sequential from record to record)

STNUML=1 Use the FORTRAN statement # as determined by IBMMET

Variable STLABR controls the line # at the left of the listing:

STLABR=0 Use LFP Line # (5 columns)

STLABR=1 Use line tags (col 73-80) of input source record (8 columns)

STLABR=2 blank field

Subroutine GET redefines these fields if a faulty LABEL control statement is processed.

14.2.2.7 I/O Units

The I/O units are defined at the end of subroutine INIT. The unit numbers referenced by the REASSIGN statements in the procedures $LFPT and the task would also have to change. See section 14.2.4

14.2.8 Comment delimiter

The comment delimiter is defined in subroutine INIT by the statement

CMTCH=SCLN

where SCLN is defined to be 59 Dec or 3B Hex.

When subroutine GET processes a faulty %COMMENT control statement the semicolon is restored as the comment delimiter.

14.2.3 Assembler Language Support.

Assembler language equivalents for the primitive character string operations have been written. The named routines on file #1 of the tape contain the following entry points.

Name	Entry Points
LFPSP1	GETCH
	PUTCH
	CHTYP
LFPSP2	PUTC
	GETC
	CPYSTR
	CATSUB
	CATNUM
	STREQ
	CATSTR
LFPSP3	TRIM
	PUTNUM

14.2.4 Link Editing

The procedure $LFPT, which is on file 1 of the tape, is used to link edit LFP. The scratch partitions referenced by $LFPT may have to change depending on the disk devices.

Fortran logical unit 1 is reassigned to the SI file which has been positioned to the file to be processed by the procedure $LPG. FORTRAN unit 2 contains the FORTRAN output (compressed ASCII). FORTRAN unit 3 is the listing output and unit 4 is the terminal output. Unit 99 is assigned to logical file (Included Input) which must have previously been assigned to a USL file.

A listing of the procedure $LFPT may be found in Figure 14-1.

14.2.5 Diagnostic Testing

File #1 of the tape contains an LFP diagnostic program DIAGLFPO. After this program is processed by LFP, the LFP listing and FORTRAN output shall compare with the listings that were sent along with the tape.

```
*D2* MC/LBL/LL SOURCE EDITOR  DATE  02/19/81  11:24:01


      1.  $PRODEFAULT LFPT,LFP,ST
      2.  $NOP PROCEDURE TO MAKE OVERLAY OF LFP
      3.  $ASS LO=NO
      4.  $ASS BI SS
      5.  $EXE LIB
      6.  GET %1
      7.  WEOF BO
      8.  EXIT
      9.  $NOTE LINK-EDIT STARTED ---
     10.  $REW BI BO
     11.  $ASS BI BO
     12.  $ASS LO=VP
     13.  $EXE M4EDIT
     14.  LIBRARIES SS,LB,MS
     15.  EDIT MAIN,BI
     16.  ASS LO=NO
     17.  WEOF BO
     18.  EXIT
     19.  $REW BI BO
     20.  $NOTE TOC STARTED ---
     21.  $EXE TOC
     22.  FILE %2
     23.  OVERLAY %1
     24.  REASSIGN 1 SI
     25.  REASSIGN 2 SC
     26.  REASSIGN 3 LO
     27.  REASSIGN 4 CO
     28.  REASSIGN 99 II
     29.  LOGFILES 4
     30.  CAT
     31.  ASS LO=VP
     32.  MAP %1
     33.  WEOF LO
     34.  EXIT
     35.  $NOP OVERLAY %1 CATALOGED ON %2 FILE
     36.  $NOTE $LFPT DONE ---
TOTAL RECORDS WRITTEN =  37

$$
```

Fig. 14-1. Link edit procedure $LFPT.

14.3 Modcomp Include Files

Source files for LFP can be included with the %INCLUDE directive. When LFP encounters this, a routine is called (CMPFLI) which reads file II searching for the included file name. If II is a USL type, the directory is searched and an error returned if not found. The position index is set to point to the start of the file. Then the file is read with consecutive calls to CMR4A which is a modified version of CMR4. If II is not a USL type file, then the position index is set to the beginning of II for CMR4A calls. Nesting of included files is not allowed.

ACKNOWLEDGMENTS

LFP (Lincoln Fortran Preprocessor) is a major extension to the FLECS preprocessor which was originally developed by Terry Beyer at the University of Oregon.

We would like to thank Terry Beyer for his permission to use selected sections of the FLECS User Manual (notably sections 1, 2, 4, 5, 6, 7 and 11) in the preparation of this report.

We would like to thank Paula Rygiel and Pam O'Connor for all the time that was spent in the preparation of the original report and thanks to Pam and Michelle Dalpe' for the work on this revised edition.

BIBLIOGRAPHY

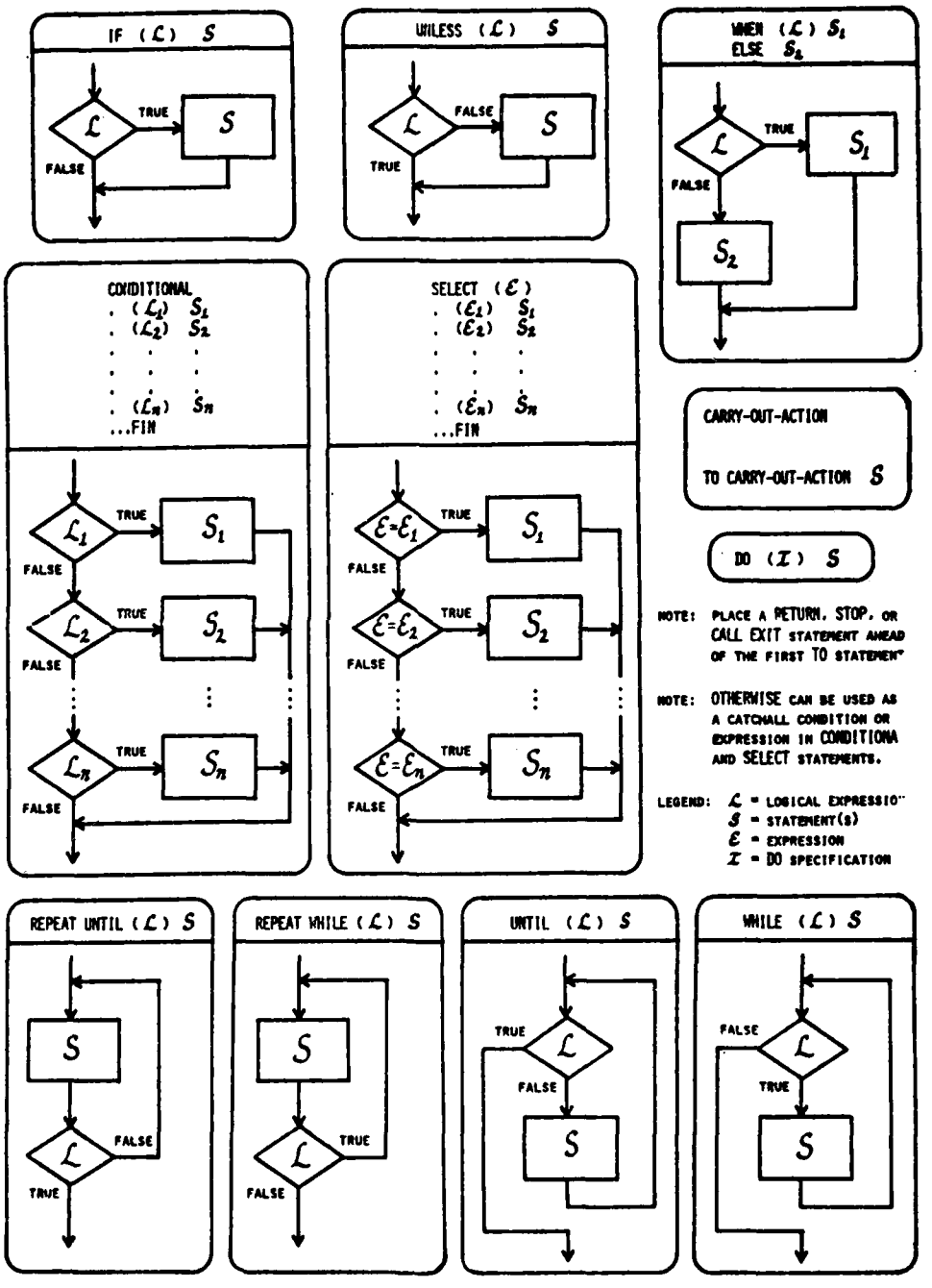
Available Documentation Concerning Flecs (As of December 1974).

Beyer, T., Flecs Users Manual (University of Oregon Edition)

Contains a concise description of the Flecs extension of Fortran and of the details necessary to running a Flecs program on the PDP-10 or the IBM S/360 at Oregon.

APPENDIX A - Control Structure Summary Sheet

(This duplicate LFP Summary Sheet may be removed from the manual)



APPENDIX B - Control Statement Summary Sheet

Section

%COMment X — 8.1.1

Define the comment delimiter character X. Default is ;

%Control X — 8.1.2

Define the control character X. Default is %

%DS — 8.1.3

Double space the LFP listing

%Heading CHARACTER STRING — 8.1.4

Define the heading CHARACTER STRING to go at the top of each page on the LFP listing.

%Include FILENAME — 8.2.1

Include the contents of the file = FILENAME in the source file. The filetype must be LFP.

%INCExp N — 8.2.2

Controls the inclusion of a file on the INCLUDE card. if N is 0 the file is not included, if N is 1 the file is included. Default = 1.

%LABEL XYZ — 8.1.5

X
- 0 CDC Fortran line numbering
- 1 IBM Fortran line numbering (default)

Y
- 0 LFP line numbers at left of listing
- 1 Fortran line numbers at left of listing (default)

Z
- 0 LFP line numbers at right of listing
- 1 Line tags at right of listing (default)
- 2 blanks

%LAdj — 8.1.6

Left adjust the source to column 7, removing blanks.

%Line N — 8.1.7

Print N lines per page. Default = 60.

%List — 8.1.8

Print LFP listing. Default.

%NOLadj — 8.1.9

Do not left adjust source to column 7 (default).

%NOList — 8.1.10

Turn off LFP listing.

%Page N — 8.1.11

Eject a page if N=0 or N is missing.
Eject a page if there are less than N lines left on a page.

%SS — 8.1.12

Single space LFP listing (default).

%Width N — 8.1.13

Width of LFP output listing in characters
Default = 133

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REPORT DOCUMENTATION PAGE

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LFP (Lincoln FORTRAN Preprocessor) provides top-down control structures to FORTRAN and generates a self-documenting structured listing. LFP is compatible with existing FORTRAN and also permits an internal procedure capability.

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